deeper parts of the vadose environment. As determined from radiocarbon dating, the stalactites have vertical growth rates of from 0.013 to 0.22 mm/yr and an average rate of lateral conical growth layer accretion of 0.006 mm/yr.

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SOME FACTORS CONTROLLING EVOLUTION OF NEAR-SURFACE DIAGENETIC FABRICS IN PLEISTOCENE CARBONATES OF BARBADOS

On the uplifted Pleistocene reef tracts of Barbados the nature and distribution of subaerial diagenetic fabrics reflect changes in 3 primary controlling factors: climate, soil, and substrate facies. These factors influence the amount and rate at which meteoric water is introduced into and held within the immediate subsurface.

Annual rainfall varies areally by a factor of 2, and evaporation, locally potentially greater than precipitation, is generally at a maximum in areas coincident with minimum rainfall. Soils grade from montmorillonitic, with an exceedingly slow rate of internal drainage, to kaolinitic, where drainage is as much as an order of magnitude faster. Substrate facies plays a subordinate but definite role in that sediments with a very open framework are incapable of retaining the pore water necessary for upward capillary transfer back to the evaporative sediment-air interface.

Subaerial fabrics are best developed in areas of low rainfall, high evaporation, and montmorillonitic soil cover. These conditions favor a local solution-reprecipitation process at or near the rock-soil-air interface. Where water is introduced into the subsurface in greater quantity or more quickly (because of higher rainfall and/or more kaolinitic soils) intense dissolution predominates, commonly with the attendant destruction of earlier formed subaerial fabrics.

Subaerial diagenesis appears to be a geologically rapid process bearing a nonlinear relation to length of exposure. Fabrics are equally well developed on successive reef tracts spanning approximately 300,000 years of exposure, and are present on subsurface discontinuities which represent breaks of only a few thousand years.

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PERMIAN PALYNOFLORAS AND THEIR BEARING ON CONTINENTAL DRIFT

By use of standardized taxonomic groups, Permian miospore assemblages were subjected to areal and temporal analysis on a global scale. The distribution patterns confirm the existence of botanic provinces and subprovinces during the Permian Period. Each botanic province has different characteristics and their geographic distribution is related to Permian latitudinal belts and sea-floor spreading.

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EXPLORATORY SUCCESS IS PREDICTABLE—EXAMPLE FROM DENVER BASIN

Analyses of Denver basin Cretaceous "D" and "J" sandstone fields reveal trends in field size and areal extent that should be helpful in predicting results of new exploration in areas with similar stratigraphy and geologic history. Within the 11-county "fairway" (excluding Arapahoe and Elbert Counties, Colorado), during the 1949–1969 period, there were 9,512 exploratory wells (11% oil, 2% gas) and 8,650 development wells (52% oil, 2% gas).

A log-log plot showing areal extent (in acres) versus ultimate oil recovery of 557 fields (218 abandoned, 339 extrapolated from production-decline curves) is a straight line and may be used in estimating the ultimate recovery of fields that have areal definition but insufficient history for extrapolatable decline curves. As an example, the 4,640-acre Peoria field (limit of present development) should have an ultimate production of 25 million bbl, if it is an average Denver basin field.

"D" and "J" production to January 1, 1970, was 560 million bbl (Colorado, 304 million bbl; Nebraska, 256 million bbl). Estimated reserves are 75 million bbl (Colorado, 37 million bbl; Nebraska, 38 million bbl). The area analyzed contains approximately 17,000 sq mi; 1,700 sq mi (10%) has oil or gas production (more than 400,000 bbl/productive sq mi). Approximately 200 of the 1,700 sq mi has gas production, but during 1971 an additional 1,000 sq mi has been added in the spaced area of Wattenberg gas field.

Oil fields were divided into 16 size classes (ultimate production), each class twice the size of the next smaller class, and the number of fields was plotted versus the size on semi-log paper. The resulting plots show a log-normal size distribution for both Colorado and Nebraska. It would have been possible, given a projected number of wildcat wells, to predict the approximate number and sizes of fields found in Nebraska from Colorado data, or vice versa.

Extension of the "fairway" into Arapahoe County and the northern townships of Elbert County should result in a predictable number of fields, and their size distribution should follow the pattern developed by past exploration. At least 60 million bbls should be added to the basin oil reserves (including Peoria), if there is sufficient exploratory drilling. Eleven percent of the wildcats should be oil discoveries and 2% of the wildcats should discover fields of one million bbls or more.

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IMPLICATIONS OF PROBABILISTIC STRATIGRAPHY

If stratigraphic correlation expresses the probability that samples from 2 different sections represent the same level in a known sequence of events, it can be considered to be the product of the probabilities that (a) the events defining the stratigraphic increment have been detected, (b) the true sequence of events is known, and (c) the events have been correctly identified. If the probability of correlation is to be greater than 0.90, each of the 3 factors must have a probability greater than 0.96. From this several important implications can be drawn.

1. If fossils are used to determine stratigraphic events, samples must generally have populations of hundreds of specimens.

2. The probability that a sequence of genetically unrelated events is correctly known reaches the required level only if sequence pairs are known from 6 sections and never occur in reverse order, or are known from 9 sections with 1 reversed occurrence, or from 12 sections with 2 reversed occurrences, or from 15 sections with 3 reversed occurrences, *etc.*

3. After 7 sections have been examined for sequences of event pairs and no reversed pairs are

known, little is gained by examination of additional sections.

4. Type sections, usually considered the objective basis of chronostratigraphy, define the level of confusion which will exist in a stratigraphic system and serve only an archival function in probabilistic stratigraphy.

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SIGNIFICANCE OF PALEONTOLOGICAL RECORD OF DEEP SEA

The cores recovered by the Deep Sea Drilling Project provide a reservoir of material for paleontologic investigation offering unparalleled opportunities to learn about the global aspects of biostratigraphy, paleobiogeography, paleoecology, paleoclimatology, paleoproductivity, changes in ocean-water chemistry, and diagenetic processes. At the time of inception of the Deep Sea Drilling Project, marine plankton fossil groups were generally poorly known except for planktonic forams. In the last few years, the calcareous nannoplankton have also been used to establish zonations for Jurassic to Holocene strata and a radiolarian zonation of the Cenozoic has been worked out. It is now feasible to evaluate differences in age-equivalent fossil assemblages in the different areas of the ocean, in different climatic zones, at different depths, and in different sediment types. Biogeographic differences, particularly between the southern ocean and the North Atlantic and North Pacific, have been detected. Distinct climatic zonation of the oceans became well established during the Late Cretaceous and has been subject to periodic intensification during the Cenozoic. The end of the Cretaceous, end of the Eocene, and the Pliocene were times of especially rapid change and evolution. The accumulations of siliceous ooze indicate regions of high productivity. Dissolution of calcareous pelagic fossils is selective, removing some species from the assemblage before others are attacked; this phenomenon offers a method of determining fluctuations of the calcium carbonate compensation depth and a means of investigating diagenetic processes in deep-sea sediments.

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GULF COAST PHOTOGEOLOGIC APPLICATIONS

A practical approach to air photo interpretation for subsurface geologists and geophysicists working in the Gulf coastal plain documents the dynamic nature of the Gulf coast surface. Surface-subsurface relations include up- and down-to-coast fault situations and their surface expressions and an explanation is given for the surface indications of deeper structure where it is not reflected in the shallow beds by seismic and well data.

The specific photogeologic criteria used for recognition of surface structure in the Gulf Coast can be demonstrated by air photos of oil fields from South Texas, North and South Louisiana, Mississippi, Alabama, and Florida. These air photos are from areas of current exploration interest such as Flomaton in southwest Alabama, the Cretaceous reef trend in central Louisiana, and the Sunniland field in south Florida, as well as some undrilled prospect situations. There are practical ways in which surface information can be used to advantage in geophysical and geological prospecting.

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DIAGNOSTIC SEDIMENTARY STRUCTURES OF MESOTIDAL BARRIER BEACHES

Depositional shorelines can be subdivided conveniently into 3 groups on the basis of tidal range: hypotidal, 0–5 ft; mesotidal, 5–10 ft; and hypertidal, > 10 ft. In terms of worldwide distribution, the 3 groups are relatively equal in occurrence. This paper deals only with mesotidal barrier beaches and is based on field studies in New England and southeastern Alaska and on a literature survey of the barrier beaches of the world.

Tidal range is significant in the formation of beach structures in that it determines the distribution and concentration of wave energy over the beach profile and generates topography that affects ebb- and flood-current systems. Beach profiles change markedly with changes in tidal phase. The most dramatic changes in the beach profile, and the most rapid sediment migration (exclusive of storm conditions), occur at spring tides. Neap tides produce unique morphologic features such as neap berms and berm-ridges.

A large diurnal inequality of the tides, such as occurs in southeastern Alaska, has a striking effect on beach morphology and on the disposition of primary structures over the beach profile. This inequality results from 4 levels of concentration of wave energy during a 24-hour period.

The most fundamental unit in producing primary structures on mesotidal beaches is the ridge-and-runnel system. High-angle beds that dip landward are produced as the ridge migrates toward shore. A complex association of structures is affiliated with the migrating ridge. Some models of the associations of primary structures produced under differing conditions of tide, beach composition, and wave climate are derived from these field and literature studies.

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COASTLINE SEDIMENTATION IN TECTONICALLY ACTIVE GEOSYNCLINAL BASIN, GLACIAL OUTWASH-PLAIN SHORELINE OF NORTHEASTERN GULF OF ALASKA

The outwash-plain shoreline of southeastern Alaska consists primarily of 2 types of coastal morphologic areas: (1) places where outwash streams border the shore, and (2) beach-ridge plains. The outwash streams provide an abundant supply of sediment to the longshore drift system. Beach-ridge plains develop as a series of prograding spits, most of which indicate sediment transport from east to west. The spits trail away from the streams that originate at the termini of large piedmont glaciers, such as the Bering and the Malaspina. Once a stream channel is abandoned, or a new outlet is found, the beach-ridge plain is eroded back at the rate of several feet per year.

The beach processes are dominated by southeasterly storms which generate exceptionally strong longshore drift from east to west. The cycle of erosion-deposition on the beaches is similar to that of the New England coast; that is, the post-storm profile is flat to slightly concave upward, the beach recovers by the landward migration of a series of ridge-and-runnel systems, and the maximum constructional phase is a broad depositional berm. The cycle is shorter on the Alaskan coast. presumably because of greater storm frequency. The